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BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Application Number: 10/673,506
Filing Date: September 30, 2003
Appellant(s): STRANG, ERIC J.

ERIC J. STRANG
For Appellant

EXAMINER'S ANSWER

This is in response to the appeal brief filed July 21, 2008 appealing from the Office action mailed February 19, 2008.

(1) Real Party in Interest

A statement identifying by name the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

The examiner is not aware of any related appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

(3) Status of Claims

The statement of the status of claims contained in the brief is correct.

(4) Status of Amendments After Final

No amendment after final has been filed.

(5) Summary of Claimed Subject Matter

The summary of claimed subject matter contained in the brief is correct.

(6) Grounds of Rejection to be Reviewed on Appeal

The appellant's statement of the grounds of rejection to be reviewed on appeal is correct.

(7) Claims Appendix

The copy of the appealed claims contained in the Appendix to the brief is correct.

(8) Evidence Relied Upon

6,802,045	Sonderman et al.	10-2004
5,583,780	Kee et al.	12-1996
2005/0016947	Fatke et al.	01-2005

(9) Grounds of Rejection

The following ground(s) of rejection are applicable to the appealed claims:

Claim Rejections - 35 USC § 101

1. 35 U.S.C. 101 reads as follows:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefore, subject to the conditions and requirements of this title.

2. Claim 66 is rejected under 35 U.S.C. 101 because the claimed invention is directed to non-statutory subject matter. A computer readable medium as claimed may include a carrier wave (see 0105 of the specification) which is non-statutory subject matter because there is no physical structure. Recommend changing to “a physical storage device” instead.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made

4. Claims 1-25, 32-56 and 66-68 are rejected under 35 U.S.C. 103(a) as being obvious over Sonderman et al. (6,802,045) in view of Kee et al. (5,583,780).

5. As to claims 1, 32, and 66, Sonderman et al. teach substantially similar claimed invention of a method and apparatus for analyzing a process performed by a semiconductor processing tool (Fig. 1-8 and its description) comprising inputting process data relating to an actual process performed by the semiconductor processing tool (process control environment 180 receives process data (process data relating an actual process being by semiconductor processing tool) from the manufacturing environment 170, at least col. 3 lines 50-64; Fig. 1); inputting a first principles physical model relating to the semiconductor tool (simulation environment 210 that includes device physics model, process model and equipment model, at least see in col. 5 lines 10-67; Fig. 3); performing a first principles simulation for the actual process being performed during performance of the actual process (col. 5 lines 10-67; col. 7 lines 1-20) using the physical model to provide a first principles simulation result (simulation data output by a simulator 340 of Fig. 3; at least col. 7 lines 37-62) in accordance with the process data relating to the actual process being performed in order to simulate the actual process being performed in order to simulate the actual process being performed (col. 3 lines 50-63; col. 4 lines 48-64; col. 5 lines 10-40; col. 7 lines 4-20; Fig. 1-3, 5, 8; col. 5-7; specifically Fig. 3 describes a simulator simulates device physics model to provide a first principles simulation data result; the device physics model 310, the process model 320 and the equipment model 330 perform the functions or conditions of the device, process, and equipment, respectively, during a particular manufacturing process, col. 5 lines 10-67; the process control environment 180 utilizes the simulation data received from the simulation environment 210 in order to make control parameter

adjustment or modifications for controlling manufacturing processes, col. 5 lines 40-47; the device physics model 310 comprises components that can measure electrical characteristics of a semiconductor wafer being manufactured; the device physics model comprises components that emulate or measure growth of oxide film on a semiconductor wafer; the device physics model 310 comprises components that can model the chemical reactions that can take place one a semiconductor wafer being processed, the process model and equipment are described (col. 5 lines 47-55); and using the first principles simulation result obtained during the performance of the actual process to determine a fault (error) in the process performed by the semiconductor processing tool (Fig. 1-8, col. 5-7; specifically the simulation environment 210 includes a process control interface 350 allowing the simulation environment 210 to perform feedback corrections during the manufacturing of semiconductor wafers, col. 5 lines 18-27; the simulation environment 210 determines any error due to variations in the components in the defined models; using this error data, the system 100 of Fig. 1 performs a predictive state analysis 750 and sensitivity analysis 760 of Fig. 7; performing the predictive state analysis comprising predictive how a certain component within one of the models 310, 320, 330 behaves in response to modifications to another component in any one of the models in order to determine an optimum component levels to be implemented during manufacturing processes, described in col. 8, lines 12-67). Sonderman et al. also teach simulating process task (actual process) to provide simulation data results to enhance manufacturing process (col. 6 lines 24-64). Specifically, Sonderman et al. teach the simulation environment including the above

integrated physical model and process model that is simulated by a simulator (Fig. 3). The teachings of the simulation environment that includes device physics model, process model and equipment model (Fig. 3, col. 5 lines 10-18, lines 47-55), clearly suggest that the models must include some equations that are used for computation in order to determine electrical characteristics, growth of oxide film, control parameters and temperature. Some of equations are described in column 9. Accordingly, Examiner believes that the simulation environment that includes a physics model, process model and equipment model correspond to physics-based first principles model. The simulation environment comprises a process control interface that allows communications between the simulation environment to receive manufacturing data from the manufacturing environment which can be used by the simulation environment to perform feedback corrections during the manufacturing of semiconductor wafers. There is an interaction performance between these models (physical model, process model and equipment model). Therefore, any modifications to any one of the three models can be made and analyzed by the simulator. The process control environment (item 180 Fig. 1) utilizes the simulation data received from the simulation environment in order to make control parameter adjustments or modifications for controlling manufacturing processes. The physics model comprises components that emulate or measure growth of oxide film on a semiconductor wafer. The device physics model also comprises components that can model the chemical reactions that can take place on a semiconductor wafer being processed. The process model and equipment model are described (col. 5 lines 47-67). Thus, Sonderman et al. do not teach the first principles

physical model including a set of computer-encoded **differential equations.** Kee et al. teach modeling apparatus that include physical models including differential equation that can be used to develop real-time control systems for a particular actual thermal system for processing a silicon wafer using physically simulations (Fig. 1-2, see summary; col. 3 lines 44-50; col. 4 lines 33-38; col. 5 lines 1517; col. 5 lines 36-45; col. 7 lines 1-10). The modeling apparatus (physical models) include a set of computer-encoded differential equations of the physical model parameters to quickly account for spectral-radiation effects used in design and real-time control systems (col. 7 lines 3-44; col. 5 lines 23-67; col. 6 lines 1-67; col. 11 lines 14-67; col. 12 lines 1-67; Figs. 1-2). Columns 7-10 describe set of differential equations. Thus, the modeling apparatus includes set of differential equations (first principles physical model that includes set of differential equations) can be used with confidence to predict effects of various approximations in the radiation transport and to facilitate the design of actual thermal systems (col. 12 lines 29-41). In addition, the modeling system with differential equation executes quickly, even when processing unit 110 is implemented on workstation class computing platform. Thus, the modeling apparatus/system 101 quickly accounts for spectral-radiation effects, and, as described above, may used in design and real-time control system for processing a semiconductor wafer (col. 7 lines 3-10; col. 5 lines 15-17; col. 5 lines 36-45). With above expected results and motivation as described above, integrating the differential equations as taught by Kee et al. in Sonderman's first principles physical model would have been obvious to practitioners in the art at the time the invention. The new added limitation, first principles simulation result being produced

in a time frame shorter in time than the actual process being performed is obvious to artisan skill in the technological art. It is well known to artisan in the art that speed of processor used to run simulation determines a time frame to produce a simulation result (first principles simulation result as taught by Sonderman). Different speed of processor is available. It is recognized to artisan skill in the art there is an advantage to obtain a simulation result ready for the actual process being performed because the simulation result is used to subsequently or sequentially or concurrently control process being performed. For at least these reasons, the newly added claimed limitation is obvious to artisan skill the art.

6. As to claims 2 and 33, Sonderman et al. teach directly inputting the data (input data, process, manufacturing data, input control parameters) relating to a process performed by the semiconductor processing tool from at least on the physical sensor and a metrology tool physically mounted on the semiconductor processing tool (Fig. 1, 7, col. 4-8).

7. As to claims 3-5 and 34-36, Sonderman et al. teach indirectly inputting the data relating to a process performed by the semiconductor processing tool from at least one of a manual input device and a database, inputting data recorded from a process previously performed by the semiconductor processing tool, inputting data set by a simulation operator (Fig. 1-3, col. 1, manual fashion and automated fashion, col.4-7).

8. As to claims 6-9 and 37-40, Sonderman et al. teach inputting data relating to at least one of the physical characteristics of the semiconductor processing tool and the semiconductor tool environment, data relating to at least one of a characteristic and a

result of a process performed by the semiconductor processing tool; inputting a spatially resolved model of the geometry (modified models) of the semiconductor processing tool; inputting fundamental equations necessary to perform first principles simulation for a desired simulation result (Fig. 1-3, col. 5-9).

9. As to claims 10-13 and 41-44, Sonderman et al. performing interaction concurrently between simulation environment (first principles simulation) and the semiconductor processing tool (Fig. 2); performing simulation environment (first principles simulation) and the semiconductor processing tool (Fig. 2); performing first principles simulation using the input data to set a boundary condition and an initial condition of the first principles simulation model (Fig. 3, col. 5-8).

10. As to claims 14 and 45, Sonderman et al. teach using the simulation result (simulation data, simulation data result) to detect a fault in the process performed by the semiconductor processing tool by comparing the first principles simulation result with the input data (col. 7, Fig. 5-7).

11. As to claims 15-19 and 46-50, Sonderman et al. teach a system having a network of interconnected resources to perform at least one of the process steps as recited in Claim 1; using code parallelization among interconnected computational resources to share the computational load of the first principles simulation; sharing simulation information among interconnected resources to determine the fault in the process performed by the simulation processing tool; distributing simulation results among the interconnected resources to reduce redundant execution of substantially similar first principles simulations by different resources; distributing model changes

among the interconnected resources to redundant refinements of first principles simulations by different resources (Fig. 1-3, computer code software is described in col. 9 starting line 58; col. 5-8).

12. As to claims 20-21 and 51-52, Sonderman et al. teach remote access (Col. 9 line 58 to col. 10 line 31). Note that a wide area network is art inherent.

13. As to claims 22 and 53, Sonderman et al. teach performing simulation utilizing a computer software code (Col. 9 line 58 to col. 10 line 31).

14. As to claims 23-25 and 54-56, Sonderman et al. teach using the first principles simulation result (simulation data set results) to classify a fault in the process performed by the semiconductor processing tool (col. 6, lines 1-35); calculating a set of perturbations solutions corresponding to the first principles simulation for input data to generate a profile data solutions to the first principles simulation, inputting the perturbation solutions to a multivariate analysis; inputting a difference between the first principles simulation result and the input data to the multivariate analysis; and utilizing the multivariate analysis to identify a correlation between the input data and the difference (defining variations into the components of defined models in order to simulate the effects of online manufacturing performance by the models; modified models) (col. 5-8).

15. As to claims 67-68, the integrated physical model as taught by Sonderman et al. and Kee et al. corresponds to a first principles physical model as claimed as described in above rejection. The simulation environment included the above integrated physical model is simulated by a simulator (Fig. 3 of Sonderman). The simulation environment

includes device physics model, process model and equipment model (Fig. 3, col. 5 lines 10-18). The simulation environment comprises a process control interface that allows communications between simulation environment to receive manufacturing data from the manufacturing environment which can be used by the simulation environment to perform feedback corrections during the manufacturing of semiconductor wafers. There is an interaction performance between these models (physical model, process model and equipment model). Therefore, any modifications to any one of the three models can be made and analyzed by the simulator. The process control environment (item 180 Fig. 1) utilizes the simulation data received from the simulation environment in order to make control parameter adjustments or modifications for controlling manufacturing processes. The physics model comprises components that emulate or measure growth of oxide film on a semiconductor wafer. The device physics model also comprises components that can model the chemical reactions that can take place on a semiconductor wafer being processed. These teachings correspond to providing for the first principles simulation a reuse of known solutions as initial conditions for the first principles simulation because the simulation data is reused as initial conditions for the simulation environment.

16. Claims 26-31 and 57-62 are rejected under 35 U.S.C. 103(a) as being obvious over Sonderman et al. (6,802,045) in view Kee et al. (5,583,780) in further view of Fatke et al. (US 2005/0016947).

17. As to claims 26-28 and 57-59, Sonderman et al. do not explicitly teach the multivariate analysis comprising a partial least square analysis; defining a set of loading coefficients, computing at least one of mean and standard deviation values. Fatke et al. teach these limitations including defining a correlation matrix in order to improve detection of a feature etch completion process during semiconductor manufacturing to thereby providing accurate and precise completion of an etch process (see abstract, Fig. 4, summary, 0051). Therefore, it would have obvious to one of ordinary skill in the art at the time the invention was made to combine these teachings in to the system as taught by Sonderman et al. in order to provide an accurate and precise completion of a process during semiconductor manufacturing.

18. As to claims 29-31 and 60-62, Sonderman et al. attributing the difference between simulated results and input data to one input data using the correlation; using the simulation result to detect a fault comprising detecting a fault (error) in at least one of a material processing system, an etch system, a photoresist spin coating system, a lithography system, a dielectric coating system, a deposit system, a rapid thermal processing system for thermal annealing and a batch diffusion furnace (examples described in col. 4; detecting a fault in at least one of a chemical vapor deposition system and a physical vapor deposition system (col. 4, 6, 7, 8).

(10) Response to Argument

19. Regarding the ***35 USC § 103*** Rejection of claims 1-25, 32-56 and 63-69 over Sonderman et al., and Kee et al..

20. Appellant argued that Sonderman et al. do not teach or suggest (specifically in bold) **performing a first principles simulation for the actual process being performed during performance of the actual process** using the physical model to provide a first principles simulation result in accordance with the process data relating to the actual process being performed in order to simulate the actual process being performed, **said first principles simulation result being produced in a time frame shorter in time than the actual process being performed,** using the first principles simulation result **obtained during the performance of the actual process.** Mainly, Appellant argued that Sonderman et al. teach performing a simulation result for a process to be performed **before** performance of the actual process and do **not** teach the claimed performing first principles simulation **for the actual process being performed during performance of the actual process**. Examiner disagrees for the following reasons. Sonderman et al. teach **performing a first principles simulation for the actual process being performed during performance of the actual process**. Sonderman et al. teach using validated models (first principles simulation model), the simulation environment 210 (simulation environment 210 shown in Fig. 1) can emulate **the operations of an actual process** control environment 180 (180 shown in Fig. 1) that is integrated with a manufacturing environment 170 (170 shown in Fig. 1). Clearly, Examiner believes that the integrated system shown in Fig. 1

used to **perform a first principles simulation for the actual process being performed during performance of the actual process** using the physical model. It is not always true as stated by Appellant that Sonderman et al. teach performing a simulation result for a process to be performed **before** performance of the actual process and do **not** teach the claimed performing first principles simulation **for the actual process being performed during performance of the actual process**. As can be seen from Fig. 1, the integrated system perform a first principles simulation (by the simulation environment 210) for the actual process (processing tools 120a, 120b) being performed during performance of the actual process (by manufacturing processes, col. 4, lines 25-30). Appellant relied upon Fig. 4 of Sonderman et al. and asserted that Sonderman et al. shows that the simulation results are produced ahead of performing a process. Examiner disagrees. In combination of Fig. 1-3 of Sonderman et al., there would have a loop back process from performing an actual process to simulation environment (although Fig. 4 not shown a loop back) because the actual process data must be used by the simulation environment (clearly shown in Fig. 1). Also the above statement by Appellant is not always true because Fig. 3 clearly shows interactions the integrated components of the integrated system shown in Fig. 1. Fig. 1 explicitly shown the actual process is performed (actual process performed by manufacturing processes using processing tools A and B); then the process data is forwarded to the simulation environment 210 shown [arrow from processing tools to simulation environment] in Fig. 1. Therefore, it is clearly that the principled simulation is performed for the actual process being performed during performance of the actual process because it is the

integrated system that provides interactions between the components shown in Fig. 1, 2, and 3.

21. Appellant also argued that Kee et al. disclose a previously generated model. Appellant argued that the simulation process as described in Kee et al. is “a lengthy and costly intensive process” and therefore would not be compatible with real-time process control in which, as defined in the claims, a first principles simulations is performed for the actual process being performed **during performance of the actual process**. Examiner disagrees. Kee et al. teach that the conventional approach which merely solves the direct problem repeatly, in lengthy and costly iterative process (col. 4 lines 22-38). Kee et al. clearly teach modeling apparatus 101 generates a model of a thermal system [physical model that includes set of differential equations] sufficiently rapidly to permit the model to be used in design of the thermal system as well as in the development of control software for the thermal system using real-time feed back from the modeling apparatus 101 (col. 3 lines 43-63; col. 5 lines 15-17; col. 5 lines 36-45; col. 6 lines 14-27; col. 7 lines 3-10). Examiner relied upon Kee et al. because Kee et al. using well known differential equations to generate first principles simulation model to permit the model to be used in design of the thermal system as well as in the development of control software for the thermal system using real-time feed back from the modeling apparatus 101 as expected (col. 3 lines 43-63; col. 5 lines 15-17; col. 5 lines 36-45; col. 6 lines 14-27; col. 7 lines 3-10). Appellant argued that the combination of Sonderman and Kee preventing Sonderman et al. from realizing a real time process control based on a first principles simulation during the actual process being performed.

Examiner disagrees. Both references teach simulating a model (e.g. first principles simulation model). Simulation is performed to mimic a process as it is an actual process. The fact is shown in Sonderman et al. (col. 7 lines 3-7). Kee et al. clearly teach modeling apparatus 101 generates a model of a thermal system [physical model that includes set of differential equations] sufficiently rapidly to permit the model to be used in design of the thermal system as well as in the development of control software for the thermal system using real-time feed back from the modeling apparatus 101 (col. 3 lines 43-63; col. 5 lines 15-17; col. 5 lines 36-45; col. 6 lines 14-27; col. 7 lines 3-10). Examiner relied upon Kee et al. of using well known differential equations to generate first principles simulation model to permit the model to be used in design of the thermal system as well as in the development of control software for the thermal system using real-time feed back from the modeling apparatus 101 as expected (col. 3 lines 43-63; col. 5 lines 15-17; col. 5 lines 36-45; col. 6 lines 14-27; col. 7 lines 3-10). Therefore, the combination would not prevent from using real-time feed back within the integrated system as taught by Sonderman et al. Regarding to the claimed processes and systems (by producing a first principles simulation result in a time frame shorter in time than the actual process being performed) permits accurate control of the process even if the system being controlled deviates from its historical behavior. The fact is that a simulation is performed faster than the actual process. The claimed never specified how much time frame shorter of a simulation performed compared a time frame performed by the actual process. Fig. 1 of Sonderman et al. clearly shown data results from processing tools (manufacturing processes) is feeding through simulation environment.

Since simulation environment performance is faster than the performance of processing tools (manufacturing processes), time frame to produce simulation results by the simulation environment is shorter than time frame performed by the actual process. Therefore, processing tools shown in Fig. 1 of Sonderman et al. do not need to wait for data result (simulation results) from the simulation environment. It is reasonable to practitioners in the art.

22. Regarding the ***35 USC § 103*** Rejection of claims 26-31 and 57-62 over Sonderman et al., Kee et al. and Fatke.

23. As clearly noted the rejection the combination of teachings would provide an accurate and precise completion of a process during semiconductor manufacturing process. In addition, using partial least square analysis, it would refine the recorded data matrix to thereby it would expect to further refine etching process (manufacturing processes performed by processing tools as taught by Sonderman et al.), by perhaps modifying parameters of first principles simulation model as taught by Sonderman et al. (col. 4 lines 18-67; col. 5 lines 1-67; col. 6 lines 1-24).

24. Regarding to the ***35 USC § 101*** Rejection of claims 66.

25. Claim 66 is rejected under 35 U.S.C. 101 because the claimed invention is directed to non-statutory subject matter. A computer readable medium as claimed may include a carrier wave (see 0105 of the specification) which is non-statutory subject matter because there is no physical structure. Recommend changing “a computer readable medium” to “a computer storage device” instead, because a computer storage device or a physical storage device has physically structure to store an executable

program. As described in the specification [0103-0105], a computer readable medium may include a carrier wave which has no physical structure to store a computer program and therefore it is non-statutory subject matter. It is noted that a computer program (program instructions) embodied on a computer readable medium or other structure, which permit the functionality of the program to be realized, would be directed to a product and be within a statutory category of the invention, so long as the computer readable medium is not disclosed as non-statutory subject matter per se (signals or carrier waves). The specification [0103-0105] clearly describes a computer readable medium may include carrier waves or signals (examples described are transmission media, light waves, radio wave, infrared signal, electromagnetic signals) which is non-statutory subject matter. For these above, Examiner respectively requests to change "a computer readable medium" to --a storage device--, which has physical structure that excludes signals or any carrier waves.

(11) Related Proceeding(s) Appendix

No decision rendered by a court or the Board is identified by the examiner in the Related Appeals and Interferences section of this examiner’s answer.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

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